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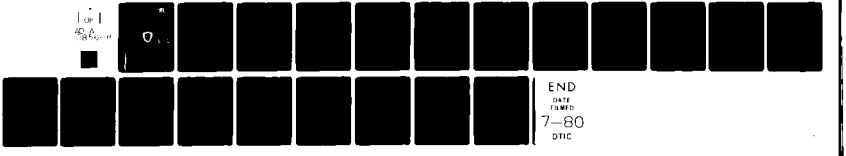

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A STUDY OF RELATIVE COST OF ARMY TOWED HOWITZERS AND COMMERCIAL CONSTRUCTION EQUIPMENT

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COST ANALYSIS DIVISION
SYSTEMS EVALUATION OFFICE
US ARMY ARMAMENT RESEARCH & DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

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A STUDY OF RELATIVE COSTS OF ARMY TOWED HOWITZERS AND COMMERCIAL CONSTRUCTION EQUIPMENT

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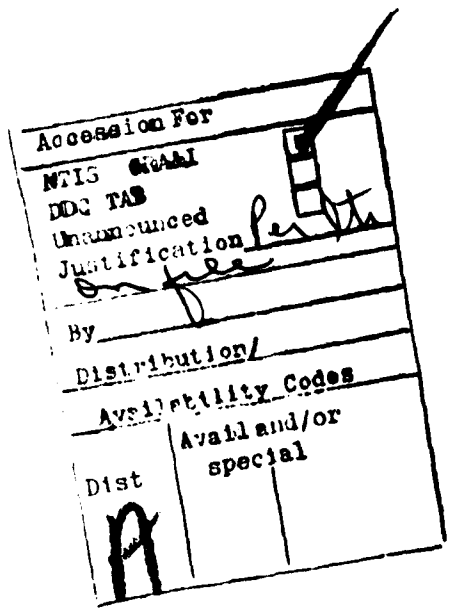

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Towed Howitzer Costs
Cost Estimating Relationship
Inflation Rates
Army Equipment

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Compares Towed Howitzer Cost to Construction Equipment on a per pound basis. Rate of inflation on Army equipment vis a vis Commercial Construction equipment. Develops a Cost Estimating Relationship for Howitzers based upon weight.

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INTRODUCTION:

This study is a current evaluation of the relative cost per pound of Army Towed Howitzers as compared to commercial construction equipment. Cost sensitivity to quantities is evaluated and the results are used to compare Towed Howitzers and commercial construction equipment on a dollar per pound basis.

The inflation rates for commercial and military equipment were examined for the 1967 to 1980 time frame, and a Cost Estimating Relationship (CER) was developed relating Towed Howitzer cost to weight.

WEAPON DATA:

Table 1, Weapon Cost and Quantity Data presents the Towed Howitzer types for which data was available and used in this study for comparative purposes. The source for columns headed Previous Data was a DF dated 8 April 1977, see Addendum 1, data has been normalized and revised for evaluation purposes in the following manner:

1) All costs escalated to FY80.

2) Fire Control costs are not included due to the level of sophistication and thus their resultant cost per pound. In addition, commercial construction equipment does not have comparable systems.

3) Costs were based upon the same quantity - 1000 units.

CONSTRUCTION EQUIPMENT DATA:

The cost and weight of commercial construction equipment is shown in Table 2. The data was obtained for Caterpillar from the Foley Machinery Company, Piscataway, NJ, and for International Harvester Company from the Pay Line Branch, South Plainfield, NJ. The costs were adjusted to FY80 using the Producers Prices and Price Index of July 1979 for Construction Machinery and Equipment as published by the Bureau of Labor Statistics.

DISCUSSION OF COST PER POUND DIFFERENTIAL:

The initial motivation for this investigation was to compare the cost per pound of Towed Howitzers and commercial construction equipment. Since the difference ranged between 15 to 25 dollars per pound, this report will attempt to explain the reasons for the difference. This study shows, Table 3, that if Learning Curve Theory is applied and the quantities of Towed Howitzers produced is increased to quantities roughly

Table 1 Weapon Cost and Quantity Data

Weapon Type	Previous Data (1) FY	Quantity	Cost/Item
M101	76	200	$ 80,879
M102	76	40	99,678
M204	76	288	96,576
M198	80	768	247,044

Weapon Type	Revised Data (2) FY	Quantity	Cost/Item
M101	80	1000	$ 91,464
M102	80	1000	89,517
M204	80	1000	115,270
M198	80	1000	237,427

(1) Except for M198, columns headed Previous Data were taken from the DF entitled "Large Caliber Soft Recoil (LCSR) 105 XM204 Towed Howitzer Comparison Analysis with Similar Weapons on a Cost Per Pound Basis" dated April 8, 1977 by Mr. L. Naef (Addendum 1). The M198 information was taken from the Exhibit P-22, Program Cost Breakdown, of 1 June 1979. Fire Control equipment is not included since construction equipment does not have comparable items particularly on a cost per pound basis.

(2) The Revised Data has been inflated to FY80 (using a multiplier of 1.438)as taken from the DRDAR-SEC Inflation Guidance of 5 Oct 79. It has been normalized based on a common quantity of 1000 and a learning curve slope of 0.90.

Table 2 Construction Equipment Data

ITEM	COST FY80 DOLLARS	WEIGHT (lbs)	COST/POUND
CATERPILLAR TRACTOR CO. (1)			
BULLDOZER TYPES			
D9	$276,120	93,900	$2.96
D8	190,463	69,950	2.72
D7	136,696	44,800	3.05
D6	100,535	31,800	3.16
D6 LGP	115,559	38,045	3.04
D5	80,919	25,700	3.15
D5 LGP	90,404	32,050	2.82
D4	56,389	18,900	2.98
D4 LGP	60,317	21,200	2.85
D3	37,837	13,600	2.78
D3 LGP	41,131	15,670	2.62
GRADER			
#14 M.G.	140,779	38,500	3.66
#12 M.G.	102,029	27,800	3.67
INTERNATIONAL HARVESTER CO. (1)			
PAY LOADER			
250 C	$130,320	45,165	$2.89
DOZER TYPES			
TD-15 C	95,040	31,520	3.01
H-90 E	135,000	37,500	3.60
H-100 L	156,600	38,880	4.02
TD-20 E	140,400	47,525	2.95
TD-25 E	194,400	71,017	2.74

AVERAGE COST PER POUND - $3.09

(1) Equipment cost and weight are based upon company catalogs.

Table 3 Comparison of Cost Per Pound of

Towed Howitzers vs Commercial Construction Equipment

Towed Howitzers:

Type	Net Weight lbs	Dollars Per Pound 10^3 Units	10^5 Units	10^6 Units
M101	4394	$20.82	$10.36	$ 7.30
M102	3073	29.13	14.49	10.21
M204	4506	25.58	12.73	8.97
M198	14940	15.89	7.91	5.57

Commercial Construction Equipment(1): (Average Cost Per Pound - $3.09)

Towed Howitzer: (Average Cost Per Pound - $8.01)

(1) Exact Quantities were not available.

comparable to that of construction equipment production (assumed to be between 100,000 and 1,000,000 units), the differential cost are reduced to a range of 5 to 10 dollars and average about 8 dollars. This differential cost can be explained by the Army's specialized requirements for durability, environmental rigor, reliability, safety, etc. The impact of competition, politics, management and testing on costs could further explain the differential.

INFLATION EFFECTS 1967-1980:

The cumulative effect of inflation over time, 1967-1980, was investigated in an attempt to determine if the Army experienced a greater rate of inflation than the private sector. The only items that could be tracked back to 1967 were the M109 Self-Propelled Howitzer and the M51 Dump Truck. The cost impact of modifications and improvements to these items could not be isolated but these factors may be hidden in the cost growth of the private sector's equipment. The results of inflation are shown in Table 4 for the 1967-1980 time frame. These results, admittedly the Army sample is quite small, show that costs to the Army have grown at an average annual rate of 3% more then private sector costs for comparable equipment. The reason for these different inflation rates may be due to the specialized requirement placed on contractors by the Army or perhaps reflect the various constraints placed upon procurement that negate market efficiences. If this trend of 3 percent per year continues, the absolute spread between the two groups will increase radically to the further detriment of Army resources.

COST ESTIMATING RELATIONSHIP (CER):

A linear regression model of the form $Y = ax+b$ was utilized with net weight as the independent variable and cost the dependent variable. The resultant equation was

$$Y = 11.64\ x + 48{,}352.27$$

Correlation Coeff. = 0.99

where

Y - cost in dollars
x - weight in pounds

Table 5, illustrates the inputs, the resultant output, and the associated error. Given the sensitive of costs to factors other than weight such as reliability, type of projectile, transportability, etc.; these results indicate that net weight would be a good predictor of cost for the Army's Towed Howitzers, particularly in the early stages of a program

Table 4 Effects of Inflation (1967-1980)

Army[1]	Costs 1967	Costs 1980	Cumulative multiplier (1967 equals 100)	Average Increase Per Year(%)
M109 SP Howitzer	$129,000	$483,000	374.4	10.7
M51 Dump Truck	11,500	51,900	451.3	12.3
			AVERAGE	11.5
Private Sector[2]				
Generic Construction Equipment	-	-	278.5	8.2

(1) The M109 and M51 cost data for 1967 was taken from the RAC Study, "Selected Uniform Cost Factors: A Manual for the Army Command, June 1972. The 1980 cost data for M109, from the June 1979 FYDP; and the M51, from the April 1978 FAMECE COEA.

(2) Private Sector costs were taken from the Producer Prices and Price Indexes, dated July 1979 and inflated to FY80.

Table 5 CER Inputs and Results

Type	Net Weight (x_i)	Actual Cost (Y_i)	Estimated Cost ($\hat{Y}_i$)	Error (%)
M101	4,394	$ 91,464	$103,907	13.6
M102	3,073	89,517	87,205	2.6
M204	4,506	115,270	105,323	8.2
M198	14,940	237,427	237,243	0.1

Comments:

The M101 and the M102 are similar weapons, but the M102 is largely made of aluminum. One of the design feature of the M198 is that it is lighter than previous 155MM howitzers.

when the tolerance bands about a cost estimate are quite large. Further regression models will be developed by the Cost Analysis Division, Systems Evaluation Office,using additional independent variables and their combinations, e.g., caliber, range of weapon, etc. At this time, net weight appears to be an acceptable predictor of cost for Towed Howitzers particularly early in the development stage when other variables are in a state of flux.

SUMMARY:

1. A study of the difference in cost per pound between Towed Howitzers and commercial construction equipment (dozers and graders) indicates that costs differs by 15 to 25 dollars per pound and averages about 20 dollars when the costs of each item are used. If the Howitzer quantities are increased to the comparable production quantities of commercial equipment and Learning Curve Theory applied, the cost per pound differential is reduced to 3 to 10 dollars per pound. This difference can be attributed to the Army's specialized requirements and competitive factor favoring commercial costs.

2. An examination of inflation from 1967 to 1980 on the price of heavy Army equipment and commercial construction equipment shows that the Army items have experienced an average inflation rate of 11 percent per year as compared to 8 percent for generic construction equipment.

3. A CER relating Towed Howitzer cost to net weight was developed which indicates that weight is an acceptable predictor of Towed Howitzer cost.

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For use of this form, see AR 340-15, the proponent agency is TAGCEN. ADDENDUM 1

REFERENCE OR OFFICE SYMBOL	SUBJECT
DRDAR-SEC	Large Caliber Soft Recoil (LCSR) 105MM XM204 Towed Howitzer Comparison Analysis with Similar Weapons on a Cost Per Pound Basis

TO Chief, SEO FROM Actg Chief, CAD DATE 8 Apr 77 CMT 1
Mr. L. Naef/pc/2896

1. Reference: Col Chesbro, DRDAR-SE, verbally tasked this office, DRDAR-SEC-S, on subject as above, 18 March 1977.

2. As tasked in reference, a cost per pound comparison was made between the 105MM XM204 Towed Howitzer (Incl 1) and the following weapon systems:

105MM M101A1 Towed Howitzer
105MM M102 Towed Howitzer
155MM XM198 Towed Howitzer

In addition to the weapons cited, a cost per pound analysis was made using Caterpillar Bulldozers and Graders. Data source is Foley Machinery Company, Piscataway, New Jersey.

3. The cost and weight data was gathered from the following sources:

XM204, M101A1, M102

Cannon - Watervliet Arsenal
Fire Control - Frankford Arsenal
Carriage and Recoil - Adapter - Rock Island Arsenal

XM198

All data was extracted from the XM198 Baseline II Cost Estimate, July 1976

4. The raw material used in the construction of the weapons is similar except for the following:

XM198 - Carriage is constructed of 56% aluminum.
XM204 - Carriage is constructed of 100% aluminum.

F M Lonshein

1 Incl
as

F. M. LONSHEIN
Acting Chief,
Cost Analysis Division

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COST PER POUND SUMMARY

	XM204	XM198	101A1	102
CANNON ASSEMBLY	$ 8.71	$ 7.34	$13.95	$ 23.77
FIRE CONTROL	113.67	61.48	92.70	176.52
CARRIAGE/RECOIL ASSEMBLY	28.16	16.19	19.84	36.07
TOTAL	$ 23.99	$14.05	$19.83	$ 37.27

a. All costs are FY76 dollars.

b. Bili package is not included except from the XM204.

CATERPILLAR

ITEM	COST FY77 DOLLARS	WEIGHT	COST/POUND
BULLDOZER			
D9	$211,640.00	93,400	2.27
D8	145,980.00	69,950	2.09
D7	104,770.00	44,800	2.34
D6	77,055.00	31,800	2.42
D6 LGP	88,570.00	38,045	2.33
D5	62,020.00	25,700	2.41
D5 LGP	69,290.00	32,050	2.16
D4	43,220.00	18,900	2.29
D4 LGP	46,230.00	21,200	2.18
D3	29,000.00	13,600	2.13
D3 LGP	31,525.00	15,670	2.01
GRADER			
#14 M.G.	107,900.00	38,500	2.80
#12 M.G.	78,200.00	27,800	2.81

XM204 HOWITZER

XM44 Carriage
XM41 Recoil Mechanism
Complete I & A
BII
Prep & Package
Quality Assurance

Producer to be determined at an estimated unit cost of $83,010

XM204 Cannon Assembly to be procured from Watervliet Arsenal, estimated unit cost of $13,566.

Commercial procurement of the Fire Control Set at an estimated cost of $14,606.

Present Plan is for initial PAA procurement in FY79.

Above estimate is in FY76 dollars and is based on an economical procurement quantity of 288 each to be procured with FY82 program authority. Reorder leadtime is 23 months.

COMPONENT WEIGHT

Cannon Assembly	1558.0 lbs.
Fire Control	128.5 lbs.
Carriage/Recoil Assembly	2948.0 lbs.
Total	4634.5 lbs

CALCULATION OF COST PER POUND

Cannon Assembly	$ 13,566	÷	1558.0 lbs.	=	$ 8.71 cost per lb.
Fire Control	$ 14,606	÷	128.5 lbs.	=	$113.67 cost per lb.
Carriage/Recoil Assembly	$ 83,010	÷	2948.0 lbs.	=	$ 28.16 cost per lb.
Total	$111,182	÷	4634.5 lbs.	=	$ 23.99 cost per lb.

M101A1 HOWITZER (1015-00-322-9752)

M2A2 Carriage
M2A5 Recoil Mechanism
Complete I & A

To be procured from Rock Island Arsenal at an estimated unit cost of $65,984.33

M2A2 Cannon Assembly to be procured from Watervliet Arsenal at an estimated unit cost of $14,895.00.

Commercial procurement of the Fire Control Set at an estimated cost per set of $7,972.46.

The M101A1 Howitzer was last procured in the early 1950's.

Above estimate is based on a minimum procurement quantity of 200 each. Estimate was completed 30 Sep 76. Orders for approximately 200 each must be received prior to initiation of procurement action. Production leadtime is 26 months. Costs are in FY76 dollars.

COMPONENT WEIGHT

Cannon Assembly	1068 lbs.
Fire Control	86 lbs.
Carriage/Recoil Assembly	3326 lbs.
Total	4480 lbs.

COMPUTATIONS OF COST PER POUND

Cannon Assembly	$14,895	÷	1068 lbs.	= $13.95 cost per lb.
Fire Control	$ 7,972	÷	86 lbs.	= $92.70 cost per lb.
Carriage/Recoil Assembly	$65,984	÷	3326 lbs.	= $19.84 cost per lb.
Total	$88,851	÷	4480 lbs.	= $19.83 cost per lb.

M102 HOWITZER (1015-00-086-8164)

M31 Carriage
M3 Recoil Mechanism
Complete I & A
Quality Assurance

To be procured from Rock Island Arsenal at an estimated unit cost of $78,377.80

M137A1 Cannon Assembly to be procured from Watervliet Arsenal at an estimated unit cost of $21,390.33.

Commercial procurement of the Fire Control Set at an estimated cost per set of $18,711.17.

Above estimate is based on program authority issued 27 Apr 76 for a quantity of 18 each M102 Howitzers with deliveries scheduled for March and April 1978. This order is being produced concurrently with an earlier order of 22 each. These are not to be considered final costs. Costs are in FY76 dollars.

COMPONENT WEIGHT

Cannon Assembly	900 lbs.
Fire Control	106 lbs.
Carriage/Recoil Assembly	2173 lbs.
Total	3179 lbs.

COMPUTATION OF COST PER POUND

Cannon Assembly	$ 21,390	÷ 900 lbs.	=	$ 23.77 cost per lb.
Fire Control	$ 18,711	÷ 106 lbs.	=	$176.52 cost per lb.
Carriage/Recoil Assembly	$ 78,378	÷ 2173 lbs.	=	$ 36.07 cost per lb.
Total	$118,479	÷ 3179 lbs.	=	$ 37.27 cost per lb.

155MM, XM198 TOWED HOWITZER

Fiscal Year 76 Dollars
Quantity 882 Units

	COST PER UNIT	WEIGHT	COST PER POUND
XM198	$ 212,052	15,092	14.05
Cannon (Steel)	35,582	4,850	7.34
Recoil Mechanism (Steel)	30,779	2,100	14.66
Fire Control (Comp.)	9,345	152	61.48
Carriage (Alum) 4,450 lbs (Steel)3,500 lbs	131,959	7,950	16.60
Integration and Assembly	4,387	-	-

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